4D Printing with Smart Materials and Its Realization

Speaker: Qi Ge

Massachusetts Institute of Technology

Singapore University of Technology and Design

Soft smart materials such as hydrogels and shape memory polymers have recently gained great attention due to their abilities of switching configurations in response to various environmental stimuli. Unique properties and advantages of these materials, however, have not been fully exploited because manufacturing and material processing for this new class of materials still rely on conventional methods. The rapid advanced 3D printing technique provides unprecedented freedom of design and manufacturing and allows us to fabricate complex 3D structures and devices with soft smart materials. The technique of printing 3D structures with active materials that change configurations over time sometimes also refers to as "4D printing".

In this talk, I will first introduce a new paradigm of *printed active composites* (PACs) that is realized by printing composites with complex and controllable anisotropic thermomechanical behavior *via* prescribing the architecture, shape, size, orientation and even spatial variation of the fibers with shape memory effects. By deliberately varying fiber volume fractions, orientations and positions, the printed laminates in thin plate form that can then be thermomechanically programmed to assume complex three-dimensional configurations including bent, coiled, and twisted strips, folded shapes, and complex contoured shapes with nonuniform, spatially-varying curvature.

The main limitations of using commercial 3D printer to fabricating active structures and devices are the material selections and costs. To overcome these limitations, I will introduce a new multi-material micro 3D printing technique developed for soft smart materials - projection micro-stereolithography (PμSL). PμSL is a 3D micro-stereolithography technology capable of rapidly building highly complex microstructures by converting photocurable resin into solid layer-upon-layer. PμSL allows us to freely tune the thermomechanical properties for shape memory polymers such as glass transition temperature, entropic elasticity, and stretchability with inexpensive commercial available materials. Using PμSL, we are able to create freely tunable shape memory composites with multi-shape memory effects and fabricate highly deformable complex 3D shape memorable devices with refined features.